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Indian Standard

METHOD FOR
DETERMINATION OF CENTRE OF
GRAVITY OF AGRICULTURAL TRACTORS

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METHOD FOR DETERMINATION OF CENTRE OF GRAVITY OF AGRICULTURAL TRACTORS

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Indian Standard

METHOD FOR DETERMINATION OF CENTRE OF GRAVITY OF AGRICULTURAL TRACTORS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 November 1983, after the draft finalized by the Agricultural Tractors and Power Tillers Sectional Committee had been approved by the Agricultural and Food Products Division Council.

0.2 To evaluate the effect of gradients on tractive effort and stability it is important to determine the position of centre of gravity of the tractor. While formulating IS : 5994 (Part 2)-1979*, a need was felt to prepare a separate Indian Standard on this subject. This standard has been prepared to fulfil this need.

0.3 This standard is complementary to IS : 5994 (Part 2)-1979*.

0.4 In preparation of this standard assistance has been derived from ISO 789/6-1982 Agricultural tractors — test procedures — Part 6: Centre of gravity issued by International Organization for Standardization. An alternative method suggested by the Tractor Training and Testing Station, Budni, has also been incorporated.

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960†.

1. SCOPE

1.1 This standard specifies method of determining the position of the centre of gravity of agricultural tractors.

2. DEFINITIONS

2.0 For the purpose of this standard, the following definitions shall apply.

*Test code for agricultural tractors: Part II Laboratory and track tests (*first revision*).

†Rules for rounding off numerical values (*revised*).

2.1 Agricultural Tractors — See 2.1 of IS : 5994 (Part 1)-1979*.

2.2 Coordinates of Centre of Gravity — See Fig. 1, 2 and 3.

2.2.1 Horizontal Fore-and-Aft Coordinate (Symbol \bar{x}) — The horizontal distance of the centre of gravity from the transverse reference plane.

2.2.2 Lateral Coordinate (symbol y) — The horizontal distance of the centre of gravity from the median longitudinal place of the tractor.

2.2.3 Vertical Coordinate (symbol \bar{h}) — The vertical distance of the centre of gravity from the horizontal reference plane.

2.3 Reference Planes

2.3.1 Horizontal Reference Plane — Ground level (a hard contact shall be assumed).

2.3.2 Vertical Reference Plane

2.3.2.1 Transverse Plane

- For wheeled tractor — Vertical plane containing the centre line of the rear axle; in case of articulated tractors locked in a straight line.
- For crawler tractor — Vertical plane containing the centre line of the driving sprocket axle.

2.3.2.2 Median Longitudinal Plane — The median plane of the wheel or track assembly is equidistant from the two planes containing the periphery of the rims or track plates respectively at their outer edges.

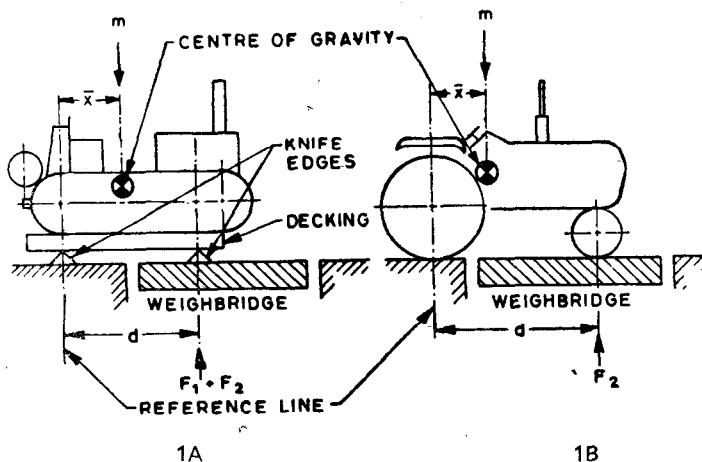
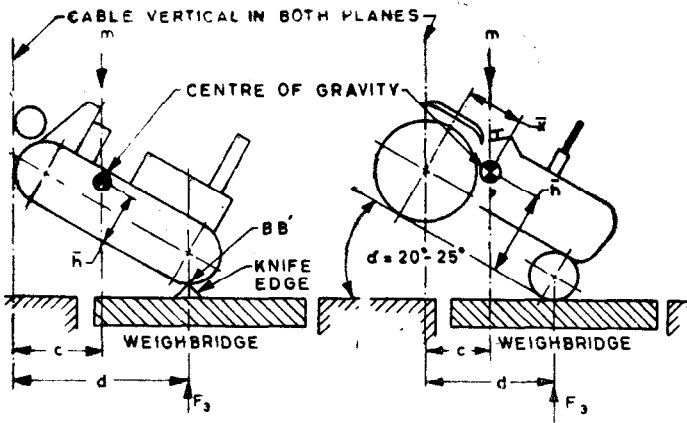
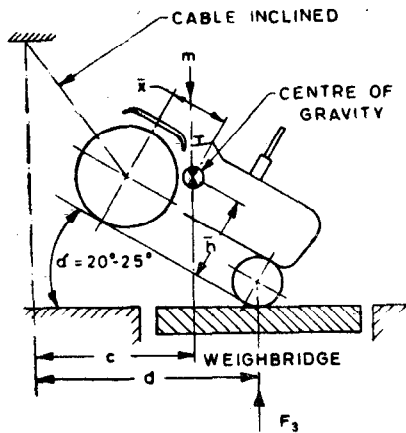


FIG. 1 DETERMINATION OF HORIZONTAL FORE-AND-AFT COORDINATE (\bar{X})

*Test code for agricultural tractors: Part 1 Terminology and general guidelines (first revision).



2A Suspension cable in vertical position



2B Suspension cable in inclined position

FIG. 2 DETERMINATION OF VERTICAL COORDINATE (\bar{h})

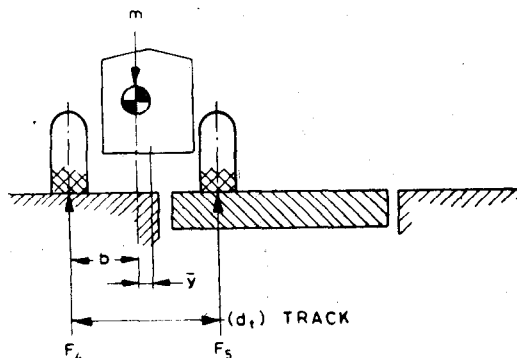


FIG. 3 DETERMINATION OF LATERAL COORDINATE IN THE HORIZONTAL PLANE (\bar{y})

2.4 Tractor Mass — The mass of the tractor as submitted for test.

2.5 Wheel Base — See 2.2 of IS : 5994 (Part 1)-1979*.

3. GENERAL

3.1 Although there are many possible methods of determining the centre of gravity, in this standard a simple practical method, which requires the use of a weighbridge and crane, has been covered. Alternatively any method may be used if they locate the centre of gravity with respect to the specified reference planes and within the specified tolerances. A suggestive alternative method is given in 8.

4. APPARATUS

4.0 The following apparatus is required.

4.1 Weighbridge or Load Cells or Strain Gauge Load Cell

4.2 Digital Load Indicator

4.3 Crane

4.4 Decking with Knife Edges

4.5 Plumb Rule

4.6 Level

4.7 Squares

*Test code for agricultural tractors: Part 1 Terminology and general guidelines (first revision).

4.8 Scribing Board — The scribing board shall be at least 600 mm high by 450 mm wide, rigidly constructed, and attached to the tractor in a suitable position with a smooth face vertical and parallel to the side or other appropriate plane.

4.9 Marking Materials

4.10 Tape Measure

5. GENERAL REQUIREMENTS

5.0 The tractor shall be clean and shall be tested in normal working conditions or in a specified condition agreed to between the manufacturer and the testing authority.

5.1 The radiator, sump, hydraulic and other reservoirs shall be filled to the specified levels; the fuel tank shall be full or empty or in a specified condition as agreed to between the manufacturer and the testing authority.

5.2 Tools, spare tyre and loose accessories and equipment shall be complete as supplied and shall be in the normal storage positions.

5.3 Tyre pressures shall be as specified in the manufacturer's operating instructions or, if a range of pressures is allowed, at the highest recommended pressure. In the case of tractors fitted with hydro-inflation tyres, they shall be filled in accordance with the manufacturer's operating instructions.

5.4 Articulated tractors shall normally be tested locked in a straight line but it may be necessary to conduct the test with condition or the joint set at the maximum or any intermediate angle.

5.5 If testing a sprung tractor, no special measure shall be taken to lock the suspension of the machine.

5.6 In conducting the test, the following measuring tolerances shall be observed:

- a) Distance — ± 0.5 percent
- b) Mass — ± 0.5 percent
- c) Tyre pressure — ± 5 percent

NOTE — Tyre pressure should be in accordance with the manufacturer's recommendations.

6. PROCEDURE

6.1 General Principle — The centre of gravity is determined by the suspension and ground reaction method. This involves measuring the ground reactions with the tractor:

- a) in a horizontal position,
- b) tilted with front end lifted, and
- c) tilted with rear end lifted.

6.1.1 The calculated horizontal distance of the centre of gravity from a ground contact point is measured in each case and verticals are drawn on the scribing board fixed to the tractor. The intersection of the verticals indicates the centre of gravity.

6.2 Determination of Horizontal Fore-and-Aft Coordinate (\bar{x})

6.2.1 Tracked Tractors (see Fig. 1A).

6.2.1.1 Determine the mass (m) of the whole tractor on the weighbridge.

6.2.1.2 Measure the reaction (F_1) under the knife edge due to its mass and part of the decking.

6.2.1.3 Move the tractor on to the decking, part supported by the weighbridge, and measure the reaction at the front knife edge due to the mass of the tractor, the decking and knife edge ($F_1 + F_2$). Calculate the reaction of the front knife edge due to the tractor mass only (F_2) by subtraction.

6.2.1.4 Measure the distance (d).

6.2.1.5 The horizontal fore-and-aft coordinate may be calculated by the following formula:

$$\bar{x} = \frac{F_2}{m} \times d$$

6.2.2 Wheeled Tractors (see Fig. 1B) — In the case of wheeled tractors, it is not necessary to use the decking or knife edges. With the brakes off, measure the axle loads and calculate \bar{x} from the mass and the wheelbase of the tractor by the formula given in **6.2.1.5** (using the wheelbase as the value for d).

6.3 Determination of Vertical Coordinate (\bar{h}) (see Fig. 2)

6.3.1 Suspend the tractor from front end at an angle of 20 to 25° to the horizontal, the other end resting on the weighbridge. The method is applicable to wheeled or tracked tractors, the main difference being in

establishing the exact location of the point of application of the ground contact. In the case of wheeled tractors, which shall be unbraked, this is vertically below the axle. In the case of tracked tractors, it is necessary to manoeuvre until the contact-grousers are in the line of ground contact BB' on either side, or to make contact through a knifeedge on the ground contact line BB' . The suspension cable shall be either vertical (*see* Fig. 2A) or inclined (*see* Fig. 2B) ensuring that the two axles shall be in horizontal position as verified by the spirit level.

6.3.2 Measure the reaction (F_3) at the ground contact on the weighbridge.

6.3.3 Measure the horizontal distance (d) from the ground contact to the point of suspension.

6.3.4 Calculate the horizontal distance from the centre of gravity to the point of suspension (c) from the following formula:

$$c = \frac{F_3}{m} \times d$$

where m is the mass of the tractor.

6.3.5 Draw a vertical on the scribing board at a distance (c) from the point of suspension.

6.3.6 Repeat the procedures specified in **6.3.1** to **6.3.5** with the tractor suspended from the rear end. The suspension angle need not be the same for both ends.

6.3.7 The intersection of the two lines on the scribing board, determined as specified in **6.3.5** and **6.3.6**, give the vertical coordinate of the centre of gravity (h).

NOTE 1 — The tractor may be conveniently run on to the weighbridge square, using chalked lines. This will assist in drawing the plan. If, in the case of tracked tractors, the grousers are not in the ground contact line BB' (*see* Fig. 2A), it is necessary to resort to trial and error by running the tractor in varying circles until the required result is attained at the last approach.

NOTE 2 — An alternative method is to use a tilting platform and load cells.

6.4 Determination of Lateral Coordinate in the Horizontal Plane (\bar{y}) (*see* Fig. 3).

6.4.1 Measure the left-hand (F_4) and right-hand (F_5) wheel or track loadings. Calculate the offset (b) of the centre of gravity using track gauge, or wheel track (d_t) as the moment arm, that is,

$$b = \frac{F_5 \times d_t}{m}$$

6.4.2 The lateral coordinate in the horizontal plane shall be calculated given by the following formula:

$$y = \frac{d_i}{2} - b$$

NOTE 1 — It is usually found that the right-hand and left-hand side loads do not exactly total the mass of the tractor due to small difference in level between the weighbridge deck and the surrounding. Any error is minimized by equalizing the overlap of the side being weighed in both cases.

NOTE 2 — It is preferable to use the total right-hand side and left-hand side wheel (track) loadings to determine the mass of the tractor (m).

7. TEST REPORT

7.1 The test report shall include the identification of the tractor and test parameters, together with the coordinate of the centre of gravity $(\bar{x}, \bar{h}, \bar{y})$ expressed in millimetres.

7.2 A suggested form of test report is given in Appendix A.

8. ALTERNATIVE METHOD

8.0 The alternative method for determination of vertical co-ordinate (\bar{h}) (see Fig. 4) given below.

8.1 Necessary fixtures may be fabricated for lifting the tractor from the front.

8.2 Determine the total mass (m) of the tractor (fitted with fixtures) with fuel, lubricants and coolants full but without ballast and 75 kg mass on the operator's seat.

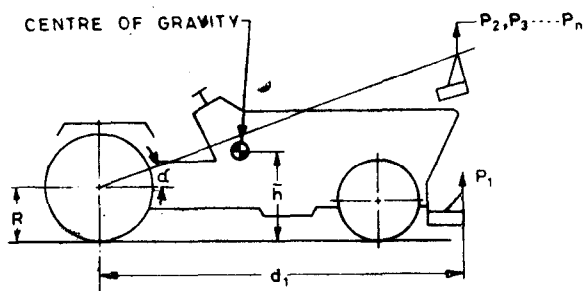


FIG. 4 ALTERNATIVE METHOD FOR DETERMINATION OF VERTICAL CO-ORDINATE (h)

8.3 Measure the horizontal distance (d_1) from the axis of the rear wheels to the plane containing the point of lifting of the tractor.

8.4 Measure the loaded radius (R) of the rear tyres at the recommended tyre pressure when the tractor rests on a horizontal surface.

8.5 The tractor is lifted with the help of crane from the front so that the front wheels are just above the ground level. Measure the load (P_1) required from lifting.

8.6 Measure the tilting angle α_1 .

8.7 Lift the tractor now at different angles (upto 25°) from the position at **8.6**. As the tractor is lifted part of the mass of the tractor at the front will be transferred to the rear and the load required to lift from front gets reduced. Measure the loads $P_2, P_3, P_4 \dots P_n$.

8.8 Measures the tilting angles $\alpha_2, \alpha_3, \alpha_4 \dots \alpha_n$.

8.9 The vertical co-ordinate \bar{h} is determined by the formula:

$$\bar{h} = R + \frac{d_1 (P_1 - P_2)}{m (\tan \alpha_2 - \tan \alpha_1)}$$

Values of \bar{h} are determined at different angles and then average of all represent the vertical co-ordinate of the centre of gravity.

APPENDIX A

(Clause 7.2)

SUGGESTED FORM OF TEST REPORT

Manufacturer's name and address

Tractor type: Model:

Serial No.

Description of the main tractor specifications influencing the position of the centre of gravity (for example, if provided with a cabin, state the type)

Tyre inflation pressures:

Front kPa

Rear kPa

Tyre size:

Front

Rear

Tractor mass (m): (for wheeled tractors)

Total kg

Front kg

Rear kg

Coordinates of the centre of gravity:

\bar{x} mm

\bar{h} mm

\bar{y} mm